DOE's SciDAC Visualization and Analytics Center for Enabling Technologies
ASCR Spring 2008 CS PI Meeting Poster Abstract

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Introduction

The SciDAC Visualization and Analytics Center for Enabling Technologies (VACET) focuses on leveraging scientific visualization and analytics software technology as an enabling technology for increasing scientific productivity and insight. Our mission is to foster scientific insight through creating and deploying effective data understanding technology that is truly responsive to the needs of our stakeholders in the scientific research community who are "awash in data." It is widely accepted that one of the bottlenecks in contemporary science is the need to gain insight from vast collections of complex data.

The vision for our Center is to respond directly to this challenge by adapting, extending, creating when necessary and deploying visualization and data understanding technologies for our science stakeholders. Organized as a Center for Enabling Technologies, we are well positioned to be responsive to the needs of a diverse set of scientific stakeholders in a coordinated fashion using a range of visualization, mathematics, statistics, computer and computational science and data management technologies.

Problem

Three primary challenges face the SciDAC visualization and data understanding communities in their quest to have a substantive impact on science and engineering. First, visualization and analytics research and development must be more attuned to the needs of SciDAC scientists and engineers. While creating scalable visualization tools is an important part of a broad strategy for meeting those needs, simply creating an image of a terabyte's worth of raw scientific data does not guarantee increased scientific insight. Indeed, if the resulting image is too complex, it will likely reduce the likelihood of discovery.

Second, visualization and analytics technologies are be designed and implemented as part of a larger technology ecosystem in which it is integrated with other complementary technologies, like data management and parallel computing infrastructure, to better meet the data understanding needs of the scientific community. These technologies need to be integral with data acquisition, management, storage, and retrieval, and be a part of a researcher's work environment rather as separate component parts or isolated islands of capability. Visualization and analytics technologies that are engineered to leverage complementary technologies in data management, parallel computing, and software engineering are much more likely to succeed at their intended purpose and are therefore more likely to be used by scientists as part of their day-to-day investigatory methodologies.

Third, visualization and analytics technology must be deployed, maintained, and supported in the computing environment. It is not enough simply to publish a visualization research paper and post source code on a web site. Scientific researchers need expert help from visualization and analytics scientists to deploy, tune, and adapt technology for their specific scientific domains. VACET's mission and scope directly addresses all of these important challenges.

Results: Production Quality, Parallel Capable AMR Visualization

VACET are leaders in production quality, parallel adaptive mesh refinement (AMR) visualization and analysis software infrastructure. We have recently deployed such production quality AMR visualization software infrastructure to SciDAC scientific researchers. This result has numerous direct benefits to those researchers. First, it allows them to "buy rather than build", thereby resulting in a direct cost savings of scientific staff: they no longer need to develop and maintain AMR visualization software. Second, the VACET technology allows them to effectively use parallel computing infrastructure to per-

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form interactive visual data analysis to help answer scientific questions in domains like combustion and astrophysics. Third, since the VACET technologies is deployed at DOE's open computing facilities as well as on the scientists' desktop, this result is an example of successfully bridging the gap across research, development and production deployment activities within DOE's science programs.

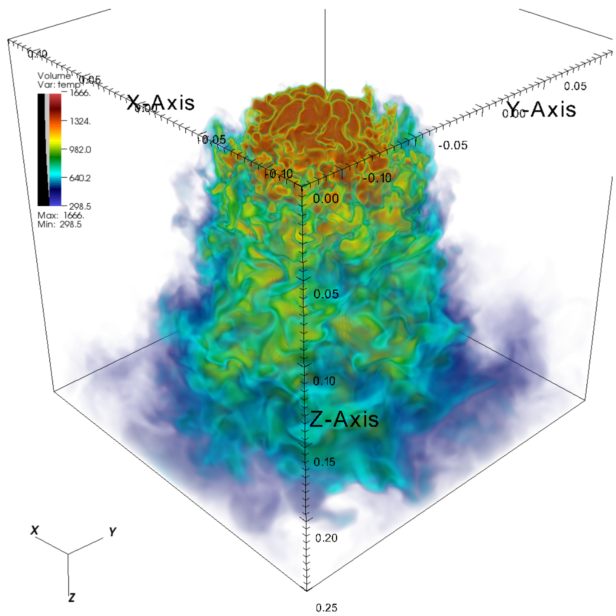

Figure 1: Production quality visualization of an AMR simulation of a hydrogen flame. Sample data courtesy of J. Bell and M. Day, Center for Computational Sciences and Engineering, LBNL.

Results: Accelerating Scientific Knowledge Discovery via Integrated Visualization and Analysis

VACET researchers developed a novel approach for analyzing the complex topology of the Rayleigh-Taylor mixing layer based on robust Morse theoretical techniques (Figure 2). This approach systematically segments the envelope of the mixing interface into bubble structures and represents them with a new multi-resolution model. With this result, it is now possible to perform a multiscale, quantitative analysis of the rate of mixing based on bubble count. The analysis highlighted and provided precise measures for four fundamental stages in the turbulent mixing process that previously scientists could only observe qualitatively, therefore enabling new insights and deeper understanding in this fundamental phenomenon (Figure 3).

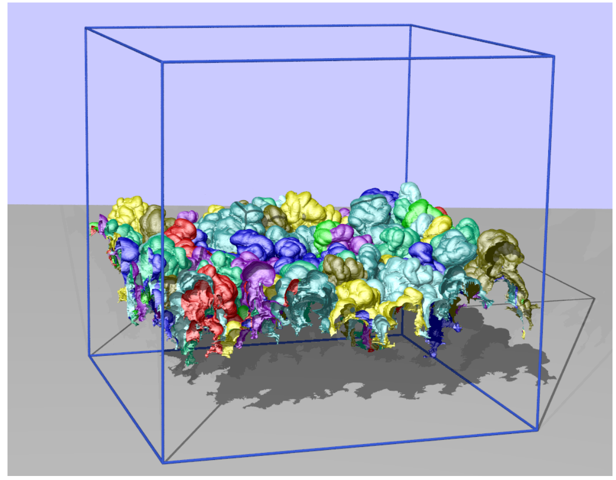

Figure 2: Topological segmentation of the bubbles emerging in the mixing interface of a Rayleigh-Taylor instability. Sample data courtesy of A. Cook and W. Cabot, LLNL.

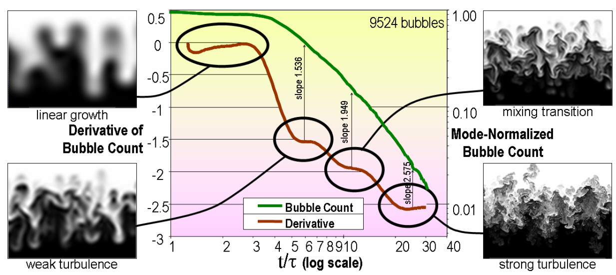

Figure 3: Quantitative analysis of a turbulent mixing simulation. The four flat regions of the derivative of the bubble count identify the four mixing stages (from early linear growth to late strong turbulence) and quantify the rate of mixing at each stage. Sample data courtesy of A. Cook and W. Cabot, LLNL.

Award-Winning Research

In addition to direct, positive impact on DOE's science community, VACET's research portfolio has generated a vast amount of field-leading work. This work includes "Best Paper Award" winners from the last two IEEE Visualization conferences.

Acknowledgment

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Contact

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